

Technical University of Denmark



## High-Tg TOPAS mPOF strain sensing at 110 degrees

**Nielsen, Kristian; Markos, Christos; Stefani, Alessio ; Yuan, Wei; Bang, Ole; Rasmussen, Henrik K.**

*Published in:*

Proceedings of 22nd International Conference on Plastical Optical Fibers (POF 2013)

*Publication date:*

2013

*Document Version*

Peer reviewed version

[Link back to DTU Orbit](#)

*Citation (APA):*

Nielsen, K., Markos, C., Stefani, A., Yuan, W., Bang, O., & Rasmussen, H. K. (2013). High-Tg TOPAS mPOF strain sensing at 110 degrees. In Proceedings of 22nd International Conference on Plastical Optical Fibers (POF 2013) (pp. 298-301). Laboratorio Instrumentacao & Fotonica (LIF).

## DTU Library

Technical Information Center of Denmark

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

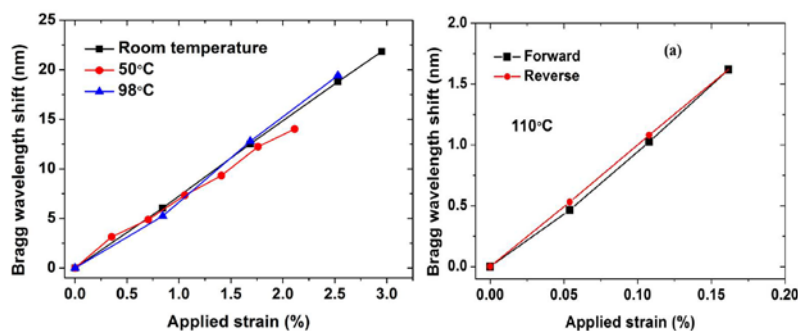
# High- $T_g$ TOPAS mPOF strain sensing at 110 degrees

K. Nielsen<sup>(1)</sup>, C. Markos<sup>(1,5,6)</sup>, A. Stefani<sup>(1,3)</sup>, H. K. Rasmussen<sup>(2)</sup>, W. Yuan<sup>(1,4)</sup>, O. Bang<sup>(1)</sup>

- 1: DTU Fotonik, Department of Photonics Engineering, Technical University of Denmark, build. 343.
- 2: DTU Mekanik, Department of Mechanical Engineering, Technical University of Denmark, build. 404
- 3: Max Planck Institute for the Science of Light, Guenter-Scharowsky Str. 1, 91058 Erlangen, Germany
- 4: Singapore Institute of Manufacturing Technology, 71 Nanyang drive, 638075, Singapore
- 5: Department of Computer Engineering and Informatics, University of Patras, Patra, 26500, Greece
- 6: Theoretical and Physical Chemistry Institute, National Hellenic Research Foundation, Athens, 11635, Greece

Corresponding author: [oban@fotonik.dtu.dk](mailto:oban@fotonik.dtu.dk)

**Abstract:** Polymer optical fibers (POFs) have several advantages compared to silica fibers. Flexibility and non-brittle nature makes them a potential platform for in-vivo biosensing applications. Their high failure strain and low Young's modulus, makes them suitable for high strain (above 1%) sensing applications and more sensitive to displacement forces. The first FBG written in a single-mode microstructured POF (mPOF), was a 1570 nm grating reported in 2005. Traditionally, POF and mPOFs have been made of PMMA, which makes the response of the FBGs dependent on both temperature and humidity. In 2011, a 1569 nm FBG was written into a TOPAS mPOF, using 325 nm UV writing [2]. Soon thereafter an 871 nm FBG in a TOPAS mPOF was reported and it was demonstrated that the TOPAS FBG was indeed humidity insensitive to within the accuracy of the climate chamber that was used [3]. In all published papers on TOPAS mPOFs, the fibers were made of the particular TOPAS grade 8007, which has a glass transition temperature of only  $T_g = 80^\circ\text{C}$ . This is even lower than that of PMMA (typically  $110^\circ\text{C}$ ), which means that the issue of a low operating temperature remains a problem for polymer FBGs. Here we demonstrate for the first time the fabrication of an mPOF made of high- $T_g$  TOPAS grade 5013 with  $T_g = 135^\circ\text{C}$ . We further inscribe FBGs into the fiber and demonstrate strain sensing of 2.5% strain at  $98^\circ\text{C}$ , further we also demonstrate strain sensing at a record high temperature of  $110^\circ\text{C}$ [4]. Taking into consideration that the TOPAS fiber is humidity insensitive and that the TOPAS FBG strain sensor may be temperature compensated using dual-FBG technology, this demonstration of high-temperature operation at  $110^\circ\text{C}$  provides a significant step towards a practically applicable polymer FBG sensor platform. It should be emphasized that there is not any report so far demonstrating the operation of PMMA POFs or mPOFs at higher temperature than  $92^\circ\text{C}$ . Overall, we believe that the current work is a significant step towards fabrication and commercialization of polymer FBG sensors based on TOPAS, which further enhances the ability of polymer fibers to operate at temperatures up to  $110^\circ\text{C}$ .



## References

- [1] Z. Xiong, G. D. Peng, B. Wu, P. L. Chu, "Highly tunable Bragg gratings in single-mode polymer optical fibers," *IEEE Photon. Technol. Lett.* **11**, 352-354 (1999).
- [2] I. P. Johnson, W. Yuan, A. Stefani, K. Nielsen, H. K. Rasmussen, L. Khan, D. J. Webb, K. Kalli, O. Bang, "Optical fibre Bragg grating recorded in TOPAS cyclic olefin copolymer", *Electron. Lett.*, **47**, 271-272 (2011).
- [3] W. Yuan, L. Khan, D. Webb, K. Kalli, H. K. Rasmussen, A. Stefani, O. Bang, "Humidity insensitive TOPAS polymer fiber Bragg grating sensor," *Opt. Express*, **19**, 19731-19739 (2011).
- [4] C. Markos, A. Stefani, K. Nielsen, H. K. Rasmussen, W. Yuan, O. Bang, "High- $T_g$  TOPAS microstructured polymer optical fiber for fiber Bragg grating strain sensing at 110 degrees", *Optics Express*, Vol. 21, Issue 4, pp. 4758-4765 (2013)